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Research Article

Bibliometric Analysis: The Application of Augmented Reality in the Field of Education in the World

Deswinta Triani[*], Midigama Liyanage Sudarshana

Abstract:

The research conducted is a bibliometric analysis related to the application of augmented reality in the field of education in the world. It aims to investigate its application in world education, how it affects students' learning skills, and provides insights for future educational practices. Utilizing the Publish or Perish tool, the research methodology employed a keyword search for "Augmented Reality" and derived from Scopus from 2018 to 2024. A specific topic of "in Education" was then chosen, yielding 52 relevant papers out of the initial 133 search articles. The Mendeley and Vosviewer apps are used to gather metadata to generate visualizations (Network and Density) of the databases containing the first and last search results. According to the research findings that have been visualized, augmented reality is required in the field of education to support the learning process itself and enhance the abilities and learning outcomes of high school students. According to earlier studies, augmented reality has a significant positive impact on both teachers and pupils when used in secondary education.

Keywords: Augmented Reality, Bibliometric Analysis, Education, Publish or Perish, Vosviewerometrik

1. INTRODUCTION

Learning is a process that involves deepening the knowledge that a teacher or expert in his field imparts. To carry out the learning process, a number of components are needed, such as media or technological tools that can balance the subject matter being taught. In this instance, a great degree of knowledge might result from the interaction between teachers and pupils (Maritsa et al., 2021; Suryadi et al., 2019). The goal of the change is to enable all educators to adjust to the rapid advancement of technology, which is so powerful that human resources may make changes early on. Competition between countries is heightened in this digital age, necessitating the improvement of human energy sources' quality (Juliarti et al., 2024).

Teachers may create more effective and varied learning experiences with the help of technology. Augmented Reality (AR) technology is one of the technologies that can be utilized in education. Because of its many potential applications, augmented reality (AR) is a novel technology that is being used in education at a rapid pace (Hasibuan & Chairad, 2023; Almiuwu,2022; Alper et al., 2021; Cabero-Almendra et al., 2019). Numerous applications created to use augmented reality in the classroom across a range of subjects stand out as examples of the contribution this educational technology has made to the area of education. However, due to a lack of teacher training, the use of this educational technology is still very limited. Teachers who wish to incorporate Augmented Reality (AR) into their classrooms must learn about it independently, outside of school hours, and in a variety of settings without sufficient resources (Amores-Valencia et al., 2022; González-Segredo dan Hernández-Cabrera, 2022).

With the advancement of technology, augmented reality (AR) gadgets can make learning difficult subjects enjoyable and simple for kids. Through virtual object interaction, students can experience lifetime learning (Yildiz, 2022; Boz, 2019). AR approaches have fundamentally altered the structure and methods of learning, particularly in the realm of education (Afnan et al., 2021; Quintero et al., 2019). In teaching, imagination is just more significant. But few people can imagine

what they discover. One of the primary reasons why pupils are not interested in learning in the classroom is this. With augmented reality, students can rapidly view three-dimensional objects that they must visualize. Augmented reality has benefited kids' general development and their capacity for imagination (Ansari et al., 2023)

Both students and teachers have responded thus far to the use of augmented reality (AR) technology in physics instruction. Teachers and students are believed to find AR-related learning materials useful both within and outside of the classroom (Apriliani et al., 2020). Because AR displays 3D graphics that are simple for students to absorb and pique their interest in learning, it offers a successful educational experience (Nurhasanah et al., 2021). It turns out that augmented reality has drawbacks in addition to benefits in education, as described by (Ansari et al., 2023) that when augmented reality is used extensively, it will keep changing in tandem with technology. Educators will find it difficult to adjust to augmented reality (AR) technology and determine how best to use it to improve health and education, as users may develop an addiction to it.

Because bibliometric analysis is a component of the research assessment process and has produced a vast amount of literature, it is necessary to see how augmented reality is being applied in the field of global education. A set of statistical and mathematical techniques used in books, journals, and other publication formats is known as bibliometric analysis (Karuniawan & Risdianto, 2023;Effendy et al., 2021). So that studies using bibliometric analysis can assist in observing the upward trend of augmented reality's use in global education

Based on the introduction that has been described, the research conducted on the bibliometric analysis of the application *of augmented reality* in the field of education in the world can examine more deeply about 1). What is the growth trend of articles on the application of *augmented reality* in the world of education from 2018-2024?; 2). What are some of the themes and keywords that often appear in articles published from 2018-2024?; and 3). The names of authors and journals who are active in publishing related articles from 2018-2024 and the number of citations?

2. MATERIAL AND METHOD

A literature review or qualitative descriptive method with a bibliometric approach was the research method employed in this study. Scientific domains are developed using the bibliometric approach, which is based on study of a selection of papers and journals from Web of Science, Crosreff, PUBMed, or Scopus (Dian & Fosterharoldas Swasto, 2021). In other words, by carefully analyzing vast amounts of unstructured data, bibliometric analysis can be used to map and analyze the cumulative scientific knowledge and evolutionary subtleties of established domains. Thus, a strong basis for advancing a discipline in a novel and significant way can be established by a well-executed bibliometric study (Donthu et al., 2021).

There were five steps in the bibliometric analysis method used in this study. In the first database search in Publish or Perish, the keyword "Augmented Reality (AR)" is defined as the first search key (Defining Search Keywords). This is one of the five processes as many as 133 relevant articles by excluding books and chapters only identified articles, then after conducting an initial search, the search results were obtained Initial *Search Result*, then the researcher narrowed the search results (*Refinement of the Search Result*) by conducting a follow-up analysis on the database of articles obtained in the initial search by filtering articles that were categorized as "education" topics because the researcher conducted research related to the topic of education, then 52 articles relevant to the topic of the article were obtained from 133 articles at the beginning, Finally, the researcher compiled statistics on the initial data (*Compiling Statistics on the Initial Data*), and data analysis (*Data Analysis*).

2.1 Defining Search Keywords

The literature search, conducted in May 2024, used the keyword *"Augmented Reality, Education"* on PoP software with a database from Scopus used to collect data. Choose Scopus sources because the scope of Scopus itself is wider than other sources and Scopus sources are suitable for use in more comprehensive bibliometric analysis than other sources that may have a wider scope. Initially, the researcher used *the keyword "Augmented Reality in Education"*, and set specific provisions for 'journals'. Here the researcher excludes

newspapers, magazines, books, book reviews, book chapters, and anything that is not an article that has been published. From the Scopus database,

133 articles in the initial search were obtained that had been published over the period from 2018-2024. It can be seen in figure 1.
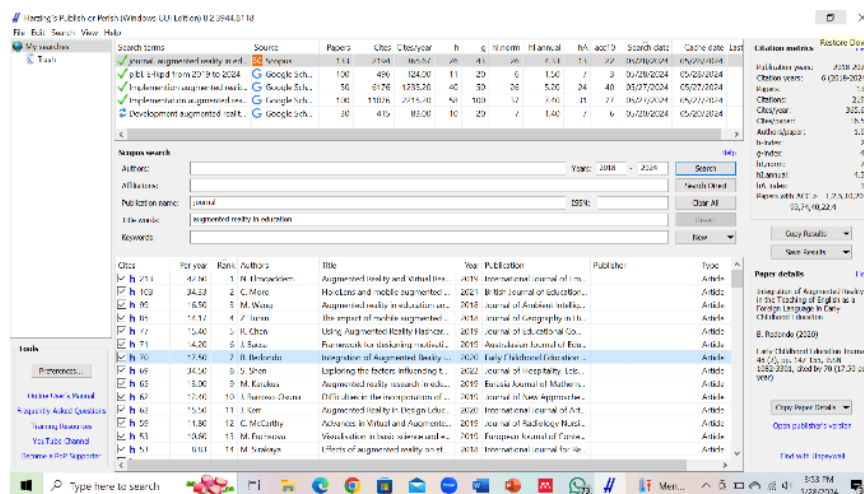

Figure 1. The initial search used the keyword "Augmented Reality in Education" with a database from Scopus

2.2 Initial Search Result

Following the acquisition of a database of 133 publications published between 2018 and 2024 that are Scopus-sourced PoPs, the top ten articles found in the Pop database are used for filtering. The top ten articles found by PoP (Unrefined Search) are listed in Table 1.

Table 1. List of the top 10 articles from the initial search of the Scopus database

Rank	Author Name	Article Title	Cites
1	N. arqaddem	Augmented Reality and Virtual Reality in Education. Myth or reality?	213
2	C. Moro	HoloLens and mobile augmented reality ini medical and health science education: A randomized controlled trial	103
3	M. Wang	Augmented reality in education and training: pedagogical approaches and illustrative case studies	99
4	Z. Turan	The impact of mobile augmented reality in geography education: achievement, cognitive loads and views of university students	85
5	R.Chen	Using augmented reality flaschcards to learn vocabulary in Early Childhood Education	77
6	J. Bacca	Framework for designing motivational augmented reality applications ni vocational educational and training	71
7	B. Redondo	Integration of augmented reality in the teaching of English as a foreign language in early childhood education	70
8	S. Shen	Exploring the factors influencing the adoption and usage of augmented reality and virtual reality applications in tourism education within the context of Covied-19 pandemic	69
9	M. Karakus	Augmented reality research in education: A bibliometric study	65
10	J. Barroso-Osuna	Difficulties in the incorporation of augmented reality in university education: Visions from the experts	62

2.3 Refinement of the Search Results

Following the initial PoP search, a database of 133 articles was retrieved from Scopus sources. The researcher then manually filtered or screened the database, separating or filtering articles within the following categories: "Irrelevant, Citation link only, not a journal, and a publication under 2019". Table 2 shows that, out of the 133 articles that were found using the initial search data, 54 were classified as irrelevant, 18 as citation-only links, 9 as publications published in 2019, 52 as educational topics, and 0 as non-journals.

Table 2. Article *Screening* Results from 133 articles recorded in the Scopus source PoP database

Search Screening	Jumlah Artikel
Irrelevant	63
Undentified/Citation Link	18
Non-Journal	0
Educational Topics	52
Total	133

2.4 Compiling Statistics on the Initial Data

The second search results are downloaded, saved in the Mendeley application, and exported in RIS format after being filtered. Complete writing information, such as the title, author's name, abstract, keywords, and journal characteristics like year, volume, publication, and page, are all included in this export. 52 articles pertinent to the discussion topic of "augmented reality in education" were found in the first category, which yielded up to 133 items. In the second search, 81 articles were eliminated from the PoP database of Scopus sources.

2.5 Data Analysis

The keyword "Augmented Reality in Education" was used in this study's analysis, and the Scopus database's "education" area was the only one that was searched. Using the PoP app, a preliminary search produced 133 articles with 2194 citations (365.67 citations annually). 52 articles remain that are classified as educational topics and pertinent to the study that was done after the search results were narrowed down using previously established categories and criteria. Subsequently, the citation data also altered, showing 1003 citations and 200.60 citations annually. Table 3 displays comparison information between the citation matrix from the first search and the most recent search.

Tabel 3. Comparison matrix of initial and final searches regarding "*augmented reality in education*"

Matriks Data	Initial Search	Refinement Search
Heading	Augmented Reality in education	Augmented Reality in education
Source	Scopus	Scopus
Citation years	2019-2024	2019-2024
Article	133	52
Citation	2194	1003
Cites Per Year	365,67	200.60
Cites Articles	16.50	19.29
Author of the Articles	1.00	1.00
h-index	26	16
g-index	43	31
hI, norm	26	16
hI, annual	4.33	3.20
hA, index	13	10

Table 3 above is the first search result and the second search result. After obtaining the results of the first search, a re-screening process was carried out, namely the second search with a more concentrated focus on the topic of "education" because the focus of this research is to see the application of augmented reality in the field of education. It can be seen from the table above that there is a change from the first search result and the second search.

3. RESULT AND DISCUSSION

After collecting data on PoP with Scopus sources, 133 articles were published from 2018-2024 related to the search term that the researcher conducted, namely *"Augmented Reality in Education"*. After obtaining and collecting data, the researcher then analyzed 52 articles relevant to this study. Where in this section will present the results of bibliographic research including the number of publications related to *augmented*

reality in education, words that often appear, then the most productive authors, and the journals that publish the most articles.

3.1 Year of Publication

In the initial search with the PoP database and sources from Scopus, 133 articles were published in 2018-2024 which were published from quite a variety of journals or journal publishers. In 2018, it turned out that there were 9 articles published or equivalent to (6.67%), then in 2019 as many as 19 articles were published that were relevant to this research or equivalent to (14.28%), in 2020 there were 13 articles published or equivalent to (9.77%), then in 2021 there were 15 articles published or equivalent to (11.27%), In 2022 there will be 31 articles published or equivalent to (23.3%), in 2023 there will be 34 articles published or equivalent to (25.56%), and in 2024 there will be 12 articles published or equivalent to (9.0%). From the analysis of the year of publication of the articles obtained, we can state that articles published from 2018-2024 have increased and decreased. Where the publication of articles has increased from 2021-2023 and has decreased the publication of articles relevant to this research in 2024.

After further screening by categorizing articles into several categories such as "irrelevant, only links, not journals, educational topics, and published under 2019", the articles, which initially numbered 133, were reduced to 52 articles relevant to this research and included in the education category. The results of the screening were obtained in 2018 and it turned out that there were no relevant articles published, in 2019 there were 11 articles published or equivalent to (21.15%), in 2021 there were 9 articles published that were relevant to this research or equivalent to (17.3%), in 2020 there were 7 relevant articles that had been published or equivalent to (13.46%), Then in 2022 there are 9 articles relevant to the research topic that have been published or equivalent to (17.3%), then in 2023 and 2024 there are 7 articles that have been published and that are relevant to this research are each or equivalent to (13.46%).

3.2 Authors and Journals who are actively publishing articles

Authors and journals who are actively publishing articles relevant to this research. The researcher analyzes the data that has gone through further filtering, in this part using PoP software to collect a database of articles relevant to the research being conducted, then the researcher downloads the data and performs visualization using *Vosviewer* with *Network Visualization* It was obtained that of the 52 articles that passed the filtering, there was no identical author in each article. It can be seen in figure 2.
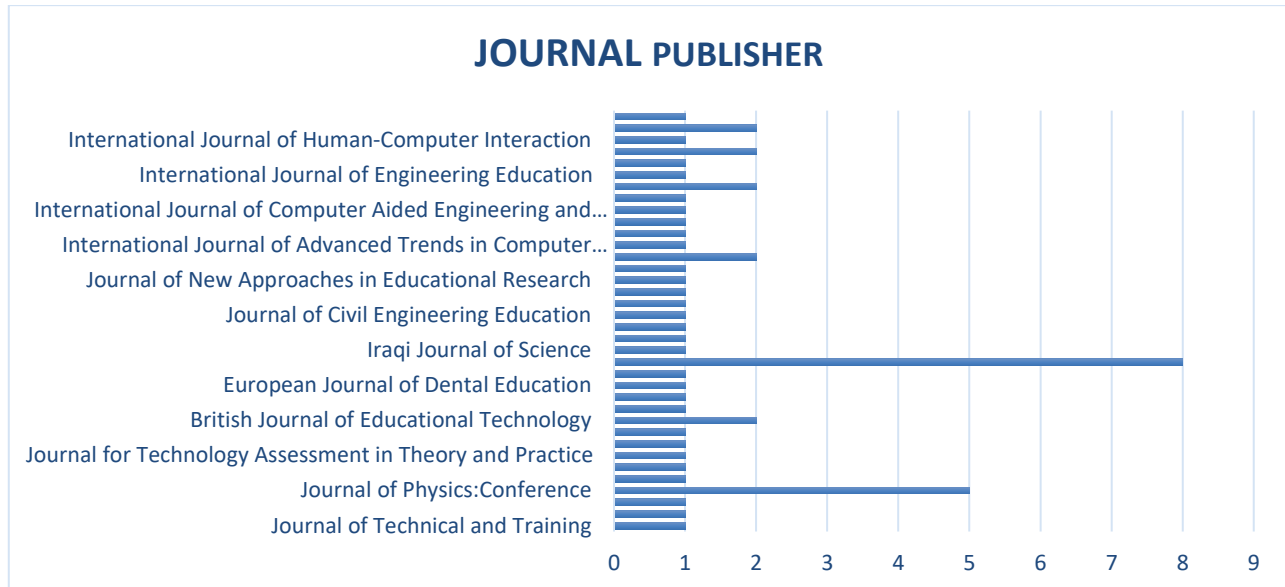

Figure 2. Popular authors 52 articles using *Netwok Visualization*

Of course, every article that has been published is certainly published through a trusted journal publisher. The researcher analyzed the names of journal publishers from 52 articles obtained from PoP with Scopus sources to see and prove whether from the 52 articles there was the same journal publisher or not. It can be seen in graph 1 that the most prolific publisher of the journal of the 52 published articles is *the International Journal of Interactive Mobile Technologies* stating that 8 articles published in the journal, where the topic of the 8 articles is relevant to *"augmented reality in education"* And the 8 articles are included in the education category published or published from 2018-2024. Then the least journal publishers publish journals that are relevant to the topic of

discussion carried out by the researcher, such as *the Journal of Technical Education and Training; Journal of Scientific and Industrial; Journal of* *Italian; etc* that have only published 1 article relevant to the researcher's topic from 2018-2024 can be seen in graph 1.

JOURNAL PUBLISHER

International Journal of Human-Computer Interaction
International Journal of Engineering Education
International Journal of Computer Aided Engineering and…
International Journal of Advanced Trends in Computer…
Journal of New Approaches in Educational Research
Journal of Civil Engineering Education
Iraqi Journal of Science
European Journal of Dental Education
British Journal of Educational Technology
Journal for Technology Assessment in Theory and Practice
Journal of Physics:Conference
Journal of Technical and Training

0 1 2 3 4 5 6 7 8 9

Graph 1. Journal of a prolific publisher from 52 articles obtained

3.3 Analysis of Frequently Appearing Words

The bibliometric analysis carried out by the researcher went through 5 stages and carried out 2 filtering or filtering of relevant articles by selecting educational topics that were in accordance with the research being conducted. In the initial search with the title "*Augmented Reality in Education*", 133 articles were obtained published from 2018-2024. Then the researcher conducted *network visualization and density visualization* using *the Vosviewer software* obtained several words that often appeared in 133 articles in the initial search. Where the words that often appear are *augmented reality, education, virtual reality, science education, higher education* and *engineering education. Vosviewer* found that the word '*augmented reality*' was found in 88 articles, the word '*education*' was found in 94 articles, the word '*virtual reality*' was found in 9 articles, the word '*science education*' was found in 8 articles, the word '*higher education*' was found in 8 articles and the word '*engineering education*' was found in 9 articles. *The network visualization* presented in figure 3 shows that the words that appear

frequently are related to other words. Meanwhile, it can be seen in the *density visualization* in this initial search result in figure 4. In figure 4, it can be seen that the words "*augmented reality*" and "*education*" have a brighter *denity* or intensity of brightness than other words, this shows that these two words appear the most in the article and have a major role in the article.

This shows that there is a link between the application of *augmented reality* in the field of education itself. Where in the first part *of the cluster* there is '*augmented reality*' which turns out to be related to *engineering education, science education,* and *higher education.* Meanwhile, in the second cluster there is '*education*' which turns out to be related to *virtual reality.* This means that in the field of education itself, sophisticated technology such as *augmented reality* can be applied and in the application *of augmented reality* this will affect the education that takes place because it indirectly presents *virtual reality* in the education. And this *augmented reality* can be applied at various levels of education such as *engineering, science* and *higher education.*
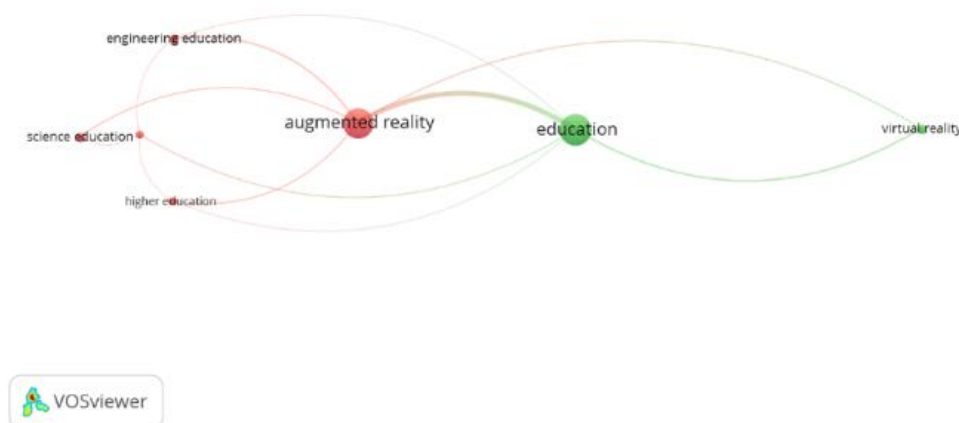
Figure 3. *Network Visualization* in the initial search results of 133 articles.

In the last search with the title "*Augmented Reality in Education*", 52 articles were obtained that passed the second filtering with relevant categories and educational topics. The article was published from 2018-2024. Then I did *network visualization* and *density visualization* using *the Vosviewer software* to get some words that often appear in 52 articles in this second search. Where the words that often appear are *augmented reality, education, learning, development, virtual reality, integration, vocation education,* and *mobile augmented reality*. In *Vosviewer* it was obtained that the word '*augmented reality'* was found in 35 articles, the word '*education'* was found in 40 articles, the word '*learning'* was found in 7 articles, the word '*integration*' was found in 3 articles, the word '*development'* was found in 5 articles, the word '*virtual reality*' was found in 4 articles, the word '*vocational education'* found in 4 articles and the word '*mobile augmented reality'* found in 4 articles. *Network visualization* can be seen in figure 3 showing that the words that appear frequently are related to other words. Meanwhile, *the density visualization* in this last search result is in figure 4. In figure 4, it can be seen that the words *"augmented reality*" and *"education*" have a brighter *density* than other words, this shows that these 2 words are the words that appear the most in the article and have a major role in the article.

This shows that '*augmented reality'* and education are related, where in the first cluster, namely augmented reality, there is *integration, vocational education, learning,* and *development*. So if in the education it applies *augmented reality* in its

learning, it will present a learning that can be indirectly said to be *virtual reality*, because the students are invited to get to know learning as if they are objects in *augmented reality* it is real and in 3D form even though in the learning it is only supported by advanced technology. So that it is very helpful for students in understanding the learning that is carried out. In the initial and final search results after the data was processed by *Vosviewer*, it can be concluded that the words that often appear or remain in the initial and second searches are the words *"augmented reality*" and *"education".* If the application *of augmented reality* helps students in learning, it is in line with previous studies that state that there are many media in science learning that can be applied in learning. In addition to teaching aids, educators can also use technology-based applications (Rahmatullah & Jumadi, 2020). The use of AR in education is promising and helps in learning (Arslan et al., 2020). With the use or application of AR in education, it will provide a new sensation in learning that initially only revolves or pivots on traditional learning, but with this AR, students are invited to participate in active learning, where students can process learning that has been done very well because of the help *of augmented reality* which depicts objects that can initially only be imagined but with AR students seem to see the object in 3D form even though it is not real. The term *augmented reality* was first proposed by Thomas Caudell and David Mizell in 1990 to describe complex electrical circuits (Elmqaddem, 2019).
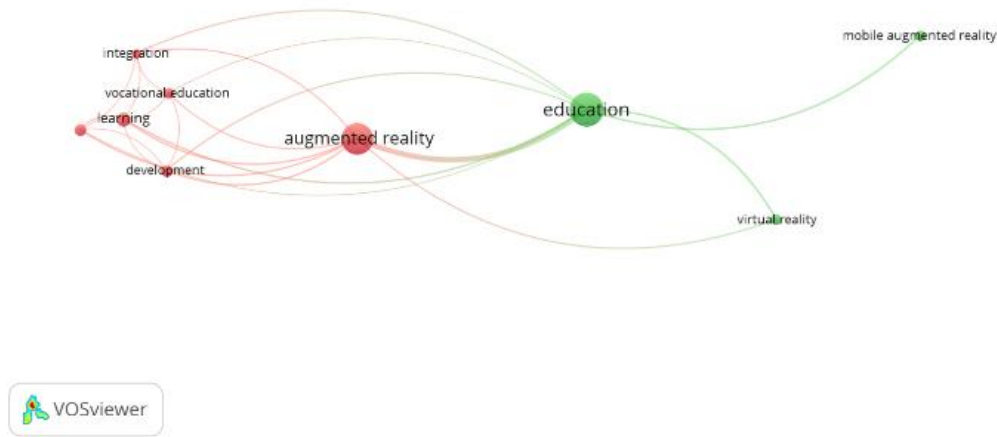
Figure 4. *Network Visualization* in the last search results of 52 articles.

From the visualization results of the first search to the second search, it was obtained that the trend of augmented reality-related publications in education showed a significant increase in recent years. Certain journals such as the International Journal of Interactive Mobile Technologies are the main places for publications on this topic, while research is widespread among various authors. An oft-recurring theme centers on the use of augmented reality as a learning tool, especially in higher education and the sciences.

4. CONCLUSION

According to the study, which used Vosviewer to visualize data on PoP from Scopus sources, as many as 52 articles relevant to the topic *of "augmented reality in education"* can be concluded that the growth trend of article publications from 2018-2024 has increased and decreased every year which is not too consistent or too decreasing because in 2024 it is still in the research stage and publication, meaning that the research conducted in 2024 is still in the process stage and is likely to be published in 2024 or the following year even though research on this topic is carried out in 2024 so it is concluded that the growth trend of the application of augmented reality in the field of education is quite large every year.

From the analysis conducted by researchers on articles from 2018-2024, the trend of research on augmented reality in education has increased with the highest number of publications in 2023. The themes that often appear are related to the use of AR technology in learning, its application in higher

education, and integration into various education systems while the keywords that often appear include "Augmented Reality", "Education", "Virtua Reality", "Learning", "Integration". Authors N. Arqaddem, C. Moro, M.Wang, and Z. Turan are figures who frequently appear in high-citation publications, while the most prolific journal is the International Journal of Interactive Mobile Technologies.

5. ACKNOWLEDGEMENT

AUTHOR INFORMATION

Corresponding Authors

Deswinta Triani, Universitas Bengkulu, Indonesia
https://orcid.org/0009-0002-2362-5188
Email: trianideswinta@gmail.com

Authors

Midigama Liyanage Sudarshana, The Open University of Sri Lanka, Sri Lanka
https://orcid.org/0000-0002-8721-0937
Email: mlsud@ou.ac.lk

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